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Expectation Management in Child-Robot Interaction

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***Abstract*— Children are eager to anthropomorphize (ascribe human attributes to) social robots. As a consequence they expect a more unconstrained, substantive and useful interaction with the robot than is possible with the current state-of-the art. In this paper we reflect on several of our user studies and investigate the form and role of expectations in child-robot interaction. We have found that the effectiveness of the social assistance of the robot is negatively influenced by misaligned expectations. We propose three strategies that have to be worked out for the management of expectations in child-robot interaction: 1) be aware of and analyze children's expectations, 2) educate children, and 3) acknowledge robots are (perceived as) a new kind of 'living' entity besides humans and animals that we need to make responsible for managing expectations.**

I. INTRODUCTION

Robot applications for children are becoming more mature and start to outgrow the toy phase. Especially in the health care domain the developments of robot applications are going rapid. For example, robots are being developed for children with diabetes [1], cancer [2], cerebral palsy [3] and autism [4]. The importance to responsibly and appropriately design child-robot interaction increases as these interactions become more elaborate and influential. This especially holds when the application targets children with special needs. When a care robot is less effective it potentially leads to a lower quality of life.

In this paper we address an issue that we found to be causing our robot application to be less effective. The drop in effectiveness occurred when children expected to have a different interaction with the robot. Our aim is to identify misaligned expectations which may need to be prevented or have to be repaired. We start with discussing the possible consequences of poor expectation management and relevant background information in section II. Secondly, in section III we identify what expectations children have of interacting with a robot in a diabetes care setting. Thirdly, in section IV we will show what happens when the expectations of children do not match with the actual interaction. Finally, we will discuss three different strategies that could help deal with misaligned expectations in section V.

II. BACKGROUND

Researchers are becoming increasingly aware that misaligned expectations can have detrimental effects on the success of human-robot interaction, see for example [5]. However, the form and role of expectations in child-robot interaction (CRI) is not as well investigated as with adults. Because CRI is fundamentally different from adult-robot interaction, as we will see later, it is important to investigate the form and role of expectations in child-robot interaction specifically.

A. Expectations in human-robot interaction

The formation of expectations of (humanoid) social robots is a complex process. First there are the preconceptions about robots [6]. It matters, for example, if people have an initial positive or negative attitude towards robots [7]. Gender [8], age [9], cultural background [10] and previous experiences [10] also play a role in forming expectations.

Besides human factors, expectations are also influenced by the morphology and behavior of robots. Humans inherently anthropomorphize (ascribe human attributes to) and zoomorphize (ascribe animal attributes to) robots [11].

In other words, people consider robots as if it were living beings, although they know they are not actually alive. The robot is not quite a human or an animal; its part of a new category of entities. For this new category a different set of social norms and protocols apply. As researchers we can help shape those protocols.

We can, for example, make use of anthropomorphism. Research shows that when a robot displays more social cues it perceived as more socially and psychically attractive by children [12].

We need to be careful however. Anthropomorphism can cause people to project certain (human) abilities on robots that do not have such abilities [5]. For example in the cerebral palsy case, if a user wrongly expects support from a robot while walking he might fall down. A bad (perceived) robot performance can lead to technology abandonment [13].

If people have a limited view of the full functionality and have low expectations of the robot, on the other hand, they are likely to use only a fraction of the functionality [14].

At this point it is important to note that when the human and the robot interact physically the relation between expectation, use and performance is more explicit and direct than during a purely social/emotional interaction [15]. As a consequence the effects of expectation misalignment become less clear.

With this paper we aim to gain more understanding by, firstly, identifying some of the expectations children have from interacting with a robot, and secondly, by investigating the consequences of misaligned expectations on the effectiveness of a socially assistive robot for children.

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B. Child-robot interaction

As discussed, anthropomorphism is one of the driving psychological forces behind the successes of human-robot interaction. Belpeame et al. (2013) found that children seem more eager to anthropomorphize robots than adults. This is strengthened by the tendency of children to play along, even if they know it is not as real as they pretend it to be. Because children are still learning a lot about language, social protocols or even common sense, they are either more oblivious or more forgiving towards the mistakes made by the robot. These properties make child-robot interaction fundamentally different from human-robot interaction with adults [16].

The differences between adults and children in HRI has led to the rise of child-robot interaction as a separate research field. Global differences between HRI and CRI research are for example the more strict ethical regulations [17] and the effects of age and gender on the appreciation of the interaction [18]. Furthermore, because evaluating robot applications with children proves to be more difficult than with adults a different set of evaluation tools is necessary [19].

C. Personal assistant for a healthy lifestyle

In the Horizon2020 project 'Personal Assistant for a healthy Lifestyle' (PAL) we are developing a robot platform that operates in several different contexts within the diabetes care domain. The robot we use is the NAO, a programmable humanoid, embodied and interactive agent developed by Aldebaran Robotics (depicted in Fig. 1). The platform's primary users are children with diabetes type I. The overall aim is to support children to become more autonomous in diabetes self-management and achieve a higher quality of life. See Blanson Henkemans et al. (2017) for the latest evaluation of the platform [20].

The 'personal assistant' comes in different forms depending on the user, location and context. For example, at the hospital a child learns more about diabetes together with the PAL-robot. At dedicated diabetes summer camps a group of children can interact together with the robot. At home children can use various mobile health applications (mHealth apps). In those apps the robot is virtually present in the form of a robot avatar [21].

MyPAL is one of the mHealth apps integrated in the PAL system. MyPAL is a digital diabetes diary that children can use to record their insulin use, carbohydrate intake and blood glucose values as well as write something about their day and how they feel (see Fig. 1). Keeping the diary is an important aspect of developing self-management skills [22].

Keeping a diary is also found to be a difficult task for the children. The goal of the avatar in myPAL is to increase diary adherence by enhancing children's intrinsic motivation. Following the Self-Determination Theory (SDT), a CRI-setting is created in which the robot and avatar aim at stimulating the childrens feeling of autonomy, competence and relatedness. For example, by positive reinforcement (as part of operant conditioning), providing constructive feedback on performance, and self-disclosure [23]. The main behavior is responding directly to added content e.g. by praising the child or by sharing a story of its own. Preliminary results show that this robot behavior is indeed effective in increasing the diary adherence and enjoyment of the children [22].

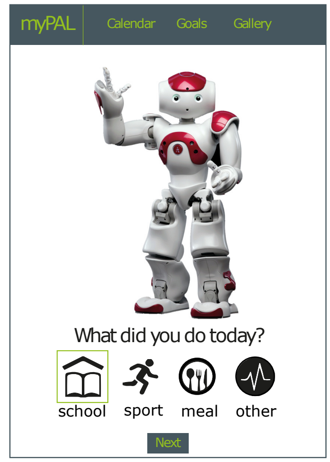

Fig. 1. Page from the myPAL digital diabetes diary including an interaction with the robot avatar

Note that the aim of this paper is not to report on the PAL project itself. We use the PAL project rather for exploring the consequences and possible solutions of misaligned expectations. The details we share about the project are meant for defining the context and not to discuss the design rationale, used methods, and results of the different PAL project experiments in full[1].

III. WHAT DO CHILDREN EXPECT?

In the orientation phase of the PAL project we performed a co-design session designed to identify the needs, values and expectations of children with diabetes [24].

A. Co-design session

The co-design session was performed during a week-long diabetes camp. Diabetes camps are organized multiple times a year by the Dutch diabetes society "Diabetesvereniging Nederland (DVN)". The PAL-project partners organized a diabetes camp with the theme "Robots and Heroes" specifically for running the pilot studies. There were 21 participants (between 8–11 y.o.; girls: 8, boys: 13), all diagnosed with diabetes type I.

The Co-design for Child-Computer Companionship suite (4C suite) was used to explore the needs and values of the children. The 4C suite consists of photo-elicitation, user journey maps and a selection of creative methods such as a draw-write-and-tell session, storytelling, and image-theater. These activities were conducted once with every child and were spread out during the week. Each activity lasted for about 1½ – 2 hours. These creative methods help to explore what the children expect, want, feel and think about the robot and the support it might provide [25].

Furthermore, there was one central event where the participants interacted with several robot and avatar prototypes.

[1]For further information and publications on the PAL project visit the PAL website: www.pal4u.eu

The children played a diabetes quiz and a sorting game with the robot and had a conversation with the avatar. The children were divided in pairs and one trio. Each pair interacted for 15 minutes before continuing to the next activity. At each activity the pairs were questioned using questionnaires and semi-structured interviews. A more detailed discussion of the co-design session can be found in [24]. In this paper we only focus on the relevant results to identify expectations.

The collected data consisted of photo's, audiovisual recordings, questionnaires, interviews and the materials produced during the 4C suite activities. We used an open coding scheme based on grounding theory to identify items concerning expectations in the material, similar as [6].

B. Results

In general the children liked the robot and are interested in it "simply because it is a robot and that is cool". The three most mentioned topics the children would like to do with the robot revolves around diabetes care, having a social conversation and simply just to have fun with it.

The participants were especially interested in practical support by the robot, e.g. physically help prick blood, inject insulin, and calculating the bolus. Furthermore, the participants indicated that they would like the robot to respond appropriately to how they feel during a conversation. The participants expected that the robot could easily detect their emotions and use that to respond accordingly. The participants also expected a more open dialogue ("We can discuss anything we want? ") than a constrained one.

Finally, the participants challenged the robot to say and do funny stuff, e.g. by saying "give a high five" or by making crazy faces and waving.

C. Discussion

The first thing that stands out is that the children expect physical support from the robot despite its visible physical limitations. Regarding the social skills of the robot the children expect that the robot will understand what they are saying and how they are feeling and they expect an appropriate response. They think they can talk about anything with the robot. The children also expect the robot to be useful to them either by supporting diabetes related activities or by having fun with it. In other words the children expect to have an unconstrained, substantive and useful interaction with the robot.

IV. EFFECT OF EXPECTATION MISALIGNMENT

With the help of the co-design session and an earlier experiment [22] we developed a digital diabetes diary with an autonomous and responsive avatar. This system was called myPAL. During the analysis of the evaluation study we discovered that some children mentioned that they had different expectations of the interaction with the robot. We decided to explore whether this might had influenced the results. The results of that exploration are reported in this section. Note that we limit ourselves here by only discussing the relevant parts of the original evaluations study. A full overview of the evaluation session is left for future work.

In short, the goal of myPAL was to increase the diary adherence of children with diabetes by supporting their intrinsic motivation to use the diary. The main mechanism to do so were the different implemented robot avatar behaviors. To evaluate the effects of the robot avatar behavior on diary adherence and motivation development we asked 13 children to use myPAL at home for three consecutive weeks. Although the children all had the same introduction session, we still found a difference in what the participating children expected from interacting with the robot avatar.

A. Method

1) Participants: 13 participants (between 7–12 y.o., 4 girls, 9 boys), all patients at the diabetes care unit of the Gelderse Vallei hospital, completed the experiment.

2) Procedure: The myPAL evaluation experiment consisted of three steps: an introduction session at the hospital, the three week use of myPAL at home and an evaluation session again at the hospital. Both sessions were individually and lasted an hour.

During the introduction session the children answered questions, where introduced to the robot and had a guided exploration of the myPAL diary. Both a questionnaire and a semi-structured interview was used to question the participants. The interviews were recorded on audio.

After the questions the participants were introduced to the PAL robot. The children played a sorting game together with the robot (see Fig. 2). It was explicitly stated that the robot cannot come home with the participants and that the robot would reply to their added diary content via the avatar.

The final element of the introduction session was a guided exploration of the myPAL diary (see Fig. 3). Given the high expectations of the conversation skills of the robot the participants were told that the avatar could only reply in a constrained way to the added diary content and that a free conversation option was not available. Due to a server error the avatar was not available during the introduction session for the first batch of participants. It was decided to leave the avatar out for all participants. This meant that none of the participants interacted with the avatar before using the diary at home.

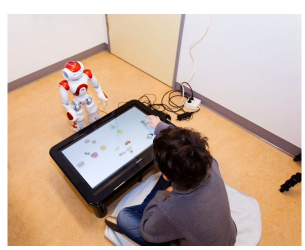

Fig. 2. Sorting game with the robot

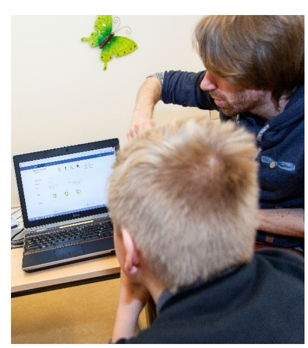

Fig. 3. Guided exploration of myPAL

MyPAL is a web application that participants could access at home through their Internet browser on a PC, laptop or tablet. Participants were instructed to use myPAL at home for three consecutive weeks whenever they wanted. Parents were instructed to remind but not force their children to add content. Half-way the children were asked to fill in a questionnaire.

The evaluation session consisted of three parts: evaluating (questionnaire and semi-structured interview), saying good-bye to (the physical) robot and thanking the participant. The robot thanked the children for their participation and stated that he enjoyed interacting with them.

3) Measures: The factors that we evaluated were diary adherence, motivation, its predecessors (feeling of autonomy, competence and relatedness), and the children's perception and appreciation of the robot avatar. Diary adherence we captured objectively by measuring the total amount and the consistency of the added content to the diary.

To measure motivation and its predecessors we used the Intrinsic Motivation Inventory (IMI) as suggested by [26]. We used questionnaires, offered by [27], at the introduction session, half way the experiment and at the evaluation session. As a measure of the total motivation during the experiment we used the area under the motivation curve (AUMC). We established the total feeling of autonomy, competence and relatedness in the same fashion.

To measure the perception and appreciation of the avatar we asked the participants to rate whether they noticed all the behaviors of the avatar, appreciated the behavior of the avatar, perceived the avatar as social and considered the avatar as important.

4) Expectation misalignment: It is important to note that measuring the expectations of the participants was not explicitly included in the evaluation. It was during the interviews that it became clear that some participants had misaligned expectations.

The interview consisted of open questions in a wide range of topics, e.g. "How did you use the diary at home?", "What do you think of the avatar?", etc. The interviewer continuously encouraged the participant to elaborate on an answer. We made transcripts of each interview and used an open coding scheme based on grounding theory [6], as before, to identify phrases that were linked to expectations. When a participant mentioned that they had different expectations, e.g. "I thought I could actually talk with the robot", the category 'misaligned expectations' was assigned to that part of the interview. These remarks give us more insight into where the misalignments occurred.

Furthermore, we divided the participants in two groups: those with misaligned expectations and those without. Now we can investigate whether there is a statistically significant difference between participants with established misaligned expectations and those without in terms of diary adherence, motivation and avatar perception.

It is important to note that the experiment had an explorative nature. The experiment was not a randomized control test (RCT); all the participants interacted under the same condition. The goal of the research was to form new hypotheses and design recommendations. Furthermore, the small number of participants makes it hard to generalize beyond CRI with children with diabetes. The results should be viewed in that context and should not be used as general causal evidence.

B. Results

Because we do not expect every dependent variable to be influenced by misaligned expectations and because of the explorative nature of the experiment we performed multiple between-subject ANOVAs to check for a statistical significant difference between both groups as recommended by [28].

4 participants were identified as having misaligned expectations leaving 9 for the second 'aligned' group[2]. In Fig. 4 the normalized means and their 95% confidence intervals of the dependent variables are displayed for both participant groups. In Table I the results of the ANOVA's are reported. Participants who had misaligned expectations were significantly less motivated to use the diary, felt less supported in their autonomy, felt less related to the robot avatar and perceived the robot avatar as less social. Furthermore, the participants also marginally added less content to the diary. All these effects are considered strong (all $\eta_p^2 > .299$).

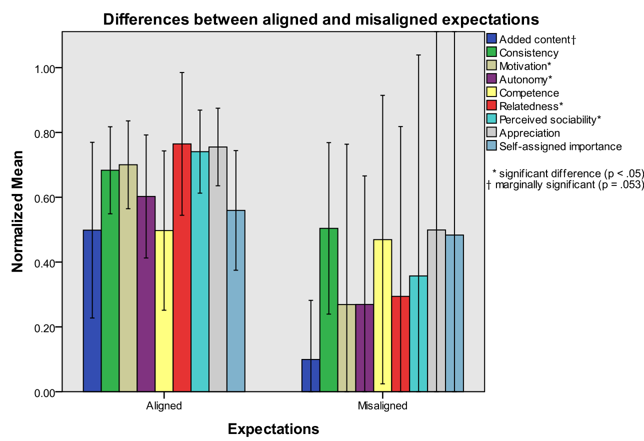

Fig. 4. Differences between aligned and misaligned expectations on diary adherence, total motivation motivation (AUMC), it's predecessors, and the perceptions of the robot avatar. The scores are normalized means (to fit all the different measures in one plot) together with the 95% confidence intervals

Let's take a closer look at what the participants with misaligned expectations said during the final interview to get a better understanding of why their expectations did not meet the actual experience. The first participant was disappointed in the quality of the interaction."It wasn't really interesting"[3]. He[4] expected more in depth conversations with the avatar.

[2]With 'aligned' we mean the participants who have not expressed misaligned expectations

[3]All quotes are translated from Dutch.

[4]We deliberately use 'he' in all the participant descriptions, although some of these items may be said by a female participant, to protect the privacy of the participant.

TABLE I
RESULTS OF THE ANOVA ON EACH DEPENDENT VARIABLE

	F(1,11)	Sig.	η_p^2	Power
Added Content	4.690	*.053*	.299	.506
Consistency	2.988	.112	.214	.352
Motivation	10.515	**.008**	.489	.839
Autonomy	5.018	**.047**	.313	.533
Competence	.022	.884	.002	.052
Relatedness	6.865	**.024**	.384	.665
Perceived Sociability	5.793	**.035**	.345	.593
Appreciation	2.715	.128	.198	.325
Importance	.182	.678	.016	.068

He indicated that the avatar's comments were sometimes inappropriate: "I wouldn't have asked this question to anyone else". The participant even mocked the avatar by mimicking what it said.

The second participant expected more interaction with the avatar."The avatar didn't really say something". He also complained that the avatar did not share anything about himself. This particular participant used the diary in such a way that encounters with the robot avatar were indeed sparse. It is important to note that the participant indicated that he was not disappointed and even though he didn't interacted with the avatar as much as he had expected he still attributed positive qualities to the avatar.

The third participant expected that he could actually chat with the avatar."I don't know if I did something wrong, but I thought I could actually talk with the avatar [...] maybe a text box where I could type something". He indicated that he was disappointed by this lack of interaction and thought the avatar was "slow" and "kinda boring".

The final participant expected that he could take the physical the robot home with him. Nevertheless, he indicated that he was not disappointed by it and that the reason for not using the diary as much was a lack of time.

C. Discussion

The results show that misaligned expectations negatively affect the effectiveness of the robot avatar in motivating the participant and stimulating diary adherence. The participants furthermore viewed the robot avatar as less social and relatable.

Two cases of misaligned expectations can possibly be contributed to misinformation. The first being the participant expecting a physical robot instead of a virtual one. The other expected to have an unconstrained conversation with the robot avatar via a chat function.

The other two participants had higher expectations of the quality and quantity of the interaction. This fits with the lower rating of avatar sociability and relatedness and with the earlier results that children expect a more natural interaction.

In both cases participants varied in whether they reported to be disappointed by their actual experiences. This could be an explanation of the relatively large variation in the scores of the misaligned group. The feeling of disappointment, i.e. the ability to cope with misaligned expectations, could be acting as a mediating factor. This exploration is left for future research.

What remains unclear is why some of the participants had misaligned expectations especially given the extensive introduction that all participants received. Were the expectations of the other participants aligned appropriately or did they adjust more quickly to the actual interaction disregarding their initial expectations? During the introduction session the avatar was not available. The participants only received a verbal explanation of its behavior and functionalities. Would an interaction with the avatar during the introduction session have prevented the misaligned expectations? We think it is likely it would have.

What becomes clear though is that misaligned expectations have a negative effect on the effectiveness of the interaction and that not all participants respond equally, e.g. are disappointed or not, to a different experience than expected. A tailored expectation management strategy seems in order. In the next section we suggest three strategies for dealing with misaligned expectations.

V. EXPECTATION MANAGEMENT STRATEGIES

The question remains of how to deal with misaligned expectations? In this section we propose three strategies to reduce, or deal with, misaligned expectations and its consequences. The evaluation of these strategies is left for future work.

The first strategy is to be aware of expectations throughout the whole robot design and evaluation process. Concrete implementations of that awareness, we are going to include in our future CRI projects, are to:

- dedicate (a part of) a pilot study to identifying the expectations the users have of interacting with a robot;
- not oversell the robot while recruiting participants or in other communications;
- address user's expectations directly with the users, e.g. by actually showing the users the absence of the wrongly expected functionalities and the presence of the actual functionalities;
- include checking for misalignments in your measurement and analysis plan. Although you (think you) have accounted for expectations in your evaluation protocol there still can be participants with misaligned expectations (as we have experienced).

The second strategy is for all of us to educate children better about the capabilities and limitations of smart technology and in particular robots. This can be done in the context of an experiment as discussed in the previous strategy. However, we propose to educate children (and adults) in a broader setting. Letting children experiment with and learn about robots and artificial intelligence in school would not only prepare them better for an experimental interaction with a robot but also for interaction with robots and intelligent and interactive applications already present, or becoming available, in the world. Concretely, we use free robot eduction as a reward for schools that participate in our user studies.

A third strategy is to acknowledge that robots are (perceived as) a new kind of entity besides humans and animals, with their own social norms and protocols. We need to make robots more responsible for, and proactive in, managing expectations. We are going to implement an interactive tutorial that allows the robot to teach the children, in a playful fashion, how to communicate with the robot.

If the robot has some notion of the expectations it elicits in its user, e.g. via a user model, it can actively attempt to correct misalignments. A more advanced method would be possible if we can establish a way to detect misaligned expectations during the interaction, e.g. a user responding surprised or confused. The robot could adapt its expectation management strategy to the situation. This is especially useful in situations when there is no room for proper education e.g. when dealing with sick children or frail elderly. Lots of work for future research.

VI. CONCLUSIONS

Our research shows that children can have the tendency to expect a more unconstrained, substantive and useful interaction with a robot than is actually possible with the current state-of-the-art. When the robot cannot deliver on those expectations, as in our case with the diabetes diary robot avatar, the effectiveness of the robot declines. Results show that the children with misaligned expectations were motived less to add content to the diabetes diary.

In the health care domain, like in our case, a lower effectiveness can lead to a lower quality of life for the children. This can be prevented by managing children's expectations properly. Therefore, we want to stress the importance of expectation management in child-robot interaction.

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